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In this work, we evaluated the electromagnetic radiation emitted from strata movement, sliding and fracture because of deeply underground mining and reveals the electromagnetic radiation dynamic nonlinear characteristics and formation mechanism in the process of surrounding rock movement. In this study, based on real-time field monitoring data, and analyse EMR temporal multifractal spectrum to explore the mechanisms for EMR generation in the process of rock burst evolution, investigated the temporal response characteristics of EMR generated by coal rock burst during underground mining, revealed the nature of nonlinear, dynamical EMR changes. The work constitutes an effort on the analysis of EME recordings after field observations. The study is of significance for us to in-depth understand EMR mechanism and to increase the accuracy of applying the EMR method to forecast dynamic disasters. Overall, it’s an innovative study.

EMR signals generated during underground mining as the fingerprint information of coal rock burst failure are closely related to microcracks nucleation (1-2 cm) and expansion of coal rock, and more closely to the inception and evolution of rock bursts. Coal rock in the hazardous zone exchanges matter and energy with the external world, and gradually evolves from a stable or equilibrium state to a non-equilibrium dissipative state, and eventually into a self-organized, critical state. EMR generation at mining face is mainly dominated by two types of microscopic mechanisms. The first one is the transient changes in stress-induced electric dipoles and electric charges due to crack-developing induced-variable motion, separation and relaxation (Gokhberg et al., 1982; Nagahama and Teisseyre, 1998; Freund 2004; Triantis et al. 2006). The second is coulomb field due to accumulation dislocation, sliding and friction of electric charges on the fracture surfaces (Miura and Nakayama. 2001; Muto et al. 2006; Akito et al. 2008). EMR signal generation is related to the dislocation and sliding of coal joints, cracks, and lattices, as well as crack development. For coal rock system at different states, the contributions of these two mechanisms are different, resulting in nonlinear, dynamic change in EMR.

Influenced by mining stress and excavation, coal rock system will spatiotemporally form multi-scale features and fractal structures, which in turn lead to emission of EMR with temporal multifractal features. The temporal multifractal spectrum of EMR intrinsically carries both spatial factor (multiple fracturing of coal rock) and temporal factor (the dynamic, temporal evolution of fractures). Therefore, it can accurately respond to deformation, rupture and failure and be used to monitor and early warn coal rock dynamic hazards.

Temporal response characteristics of EMR show that the process of coal rock burst evolution involve inception, development and critical stages. At the inception stage, coal rock undergoes elastic compaction and micro-crack nucleation. Thus, radiated EMR signals are contributed mainly by micro crack extension, meaning $\Delta\alpha_m$ is small and Δf_m is mostly less than zero. At the development stage, cracks rapidly expand, connect to each other and form multi-scale fissures, which further damage coal rocks and accelerate plasticity and shear sliding failure. During this period, the measured EMR signals are contributed mainly by crack extension and shear slidding and $\Delta\alpha_m$ and Δf_m increase gradually. At the critical stage, coal rock system steps into the self-organized, critical state, $\Delta\alpha_m$ decreases slightly and Δf_m fluctuates around zero, the system is prone to burst failure due to disturbances.

Although dynamic multi-fractal spectrum of EMR is an objective response to deformation and failure of the loaded coal rock and can be used to evaluate the deformation and fracture process and failure of coal rocks. However, the fractal parameters $\Delta\alpha_m$ and Δf_m of EMR are affected by various factors, including loading rate as well as the mechanical properties and stress levels of coal rock. Therefore, the dynamic changes in the multifractal parameters $\Delta\alpha_m$ and Δf_m and their impacting factors need to be further investigated.